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ABSTRACT

A brief overview of the language of mathematics is presented, with specific attention given to its structure and facility. It is felt that professional discretion has to be exercised as to which elements of the material are acceptable for student use. However, it is viewed as essential that teachers be exposed to the structure in order to deal more proficiently with pupils' apparent inability to understand. Five parts of mathematical speech are noted: (1) Number Symbols, (2) Operation Symbols, (3) Relation Symbols, (4) Grouping Symbols, and (5) Placeholder Symbols. The nature of mathematical expressions, which pull together symbols in meaningful combinations, is discussed. The translation of expression from mathematics to English is reviewed. It is felt that understanding this translation process will help students be better prepared for analysis in problem-solving situations, and avoid defeat at the hands of story problems. (MP)

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Language of Mathematics

GRADES 6–12

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Indiana Department of Public Instruction
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THE LANGUAGE OF MATHEMATICS (6-12)

Introduction

The cry is heard in classrooms across the nation and probably around the world. It begins in September and frustrates mathematics teachers at all levels. "But what do they want us to do?" "Do we just work them?" "I don't understand the instructions."

Why is it that students have such difficulty comprehending the directions for sets of problems in mathematics texts? Several possible reasons surface immediately. The technical vocabulary of mathematics may be too sophisticated and/or polysyllabic. The child may not really understand the "examples on the board." The interchangeability of terms may confuse the child. The child may be prejudging on the basis of past experience with laboriously involved explanations for sets of problems.

There may be other factors, but one element seems to be present throughout. The student doesn't understand (and probably has never been exposed to) the structure of the language of mathematics. It can be demonstrated very quickly and easily that students can grasp the language of mathematics at least as efficiently as the written form of the spoken language. In fact, what seems at first to be just a jumble of symbols turns out to be a much more manageable group of expressions than the myriad of combinations at our disposal in the English language.

The following, then, is a brief overview of the language of mathematics, with specific attention given to its structure and facility. Professional discretion will have to be exercised as to which elements of the material are acceptable for student

use, but it is essential that teachers be exposed to the structure in order to deal more proficiently with the student's apparent inability to understand.

Parts of Speech

The first thing we may notice about mathematics is that there do exist, in fact, mathematical parts of speech. In the English language it has been traditionally accepted that there are eight parts of speech. In mathematics, however, there are only five. The following chart illustrates these five types of symbols, examples of each, and, when applicable, their counterparts in the English language. For example, the first "part of mathematical speech" considered is the number symbol. Number symbols are the "things" of mathematics and correspond to the "things" of English, i.e., nouns, pronouns.

The Five Parts of Mathematical Speech
(Five Groups of Mathematical Symbols)

Symbol Type	Example	English Counterpart
I. Number Symbols (the "things" of mathematics)	1,2,3...I,II,III...$\frac{1}{2}$,$\frac{1}{4}$...	nouns
II. Operation Symbols (the "actions" of mathematics)	+,-,x,-...U,$\cap$...$\sum$...	verbs
III. Relation Symbols (the "comparisons" of mathematics)	=,$<$,$>$,$\neq$,$\geqslant$...	conjunction
IV. Grouping Symbols (the "punctuation" of mathematics)	(),[],{}...	------
V. Placeholder Symbols (the "blanks" of mathematics)	a,b,c...□,△...?...	------

It is important to note that further study in mathematics does not introduce new types of symbols but does extend the list within the existing types.

Mathematical Expressions

The next step in "conquering" the language of mathematics is, of course, putting various types of symbols together in meaningful combinations. Recalling our experiences in English grammar, we remember that an expression had to include a subject and predicate to be a complete sentence. Likewise, in mathematics there are certain essentials. A mathematical expression must have a right-hand member, a left-hand member and a relation symbol between them. This is further clarified by the following chart which also illustrates the "inevitable set of instructions" accompanying each type. For example, the first expression, 3 + 4, has no placeholder (see Parts of Speech) and therefore is not subject to modification. Thus, it is referred to as <u>closed</u>. Neither is there a relation symbol (see Parts of Speech), so we must refer to this expression as a <u>phrase</u> instead of a complete sentence. Now, the only thing we can do with such an expression is <u>evaluate</u> it, giving us, for this example, 7.

EXPRESSIONS IN MATHEMATICS

CLOSED PHRASE	OPEN PHRASE
Ex. 3 + 4 no placeholder no relation	Ex. 5 · n has placeholder no relation
SO...Evaluate	SO...Substitute and Evaluate
Ex. 7	Ex. Domain = {1,2,3} Range = {5,10,15}
CLOSED SENTENCE	**OPEN SENTENCE**
Ex. 3 + 4 = 8 no placeholder has relation	Ex. $20 < 5 \cdot n$ has placeholder has relation
SO...True or False	SO...Substitute & True or False
Ex. False	Ex. Replacement = {1,2,3} Solution = { }

Two points are noteworthy here. First, it should be rather obvious that there is a sequential development relating to corresponding student experience by grade level. Second, we begin to see an impact on the types of activities which can be immediately related to relieving fears associated with the instructions given for problems in the text.

The following are some examples with illustrations of what can be done with each. The domain or replacement set used, if necessary, is {0,1,2,3}.

	EXPRESSION	IDENTIFICATION	WHAT CAN BE DONE
1.	$6 + 8(3)$	Closed Phrase	30
2.	$m + 2$	Open Phrase	Range = {2,3,4,5}
3.	$5 - z = 4$	Open Sentence	Solution = {1}
4.	$8 - 2^3 = 4 - 2$	Closed Sentence	False
5.	$\frac{12 + 8}{5} \neq 2 \cdot 2$	Closed Sentence	False
6.	$W^2 - W$	Open Phrase	Range = {0,2,6}
7.	$9y$	Open Phrase	Range = {0,9,18,27}
8.	$\frac{15 + 18}{3} = 5 + 6$	Closed Sentence	False
9.	$3K + 11 < 17$	Open Sentence	Solution = {0,1}
10.	$2\ 4 - 1$	Closed Phrase	7
11.	$3 + (X + 5)^2 = 19$	Open Sentence	Solution = { }
12.	5,237,614	Closed Phrase	5,237,614

Translation

The culmination of the study of structure in the language of mathematics is, of course, to be able to translate from mathematics to English. Not only does this enhance and reinforce the student's understanding of mathematics symbolism but it is very helpful in a formal approach to solving "story" problems.

The simplest way to see this process initially is to show, in chart form, the correspondence between mathematics symbols and English expressions. What follows, then, is such a chart, developed sequentially by looking at each of the five parts of mathematics speech and then considering each of the symbols involved.

It should be noted that this listing is by no means exhaustive. Neither should it be considered as a panacea. It will relieve, however, some of the paranoia associated with instructions such as, "Just think about it," or "Just reason it out logically." For example, if a story problem author uses the word "total" we see that the operation involved must be addition. If the author uses the expression "is greater than," the relation symbol ">" must be indicated.

MATHEMATICS ⟷ ENGLISH

Mathematics Symbol	English Symbol
I. Number Symbols	-the word for the number will be used or the actual numeral will be given.
II. Operation Symbols	
A. +	-add, plus, increase, sum, total, "positive," combined, gain, rise, climb, "a certain number more than"...
B. -	-minus, subtract, decrease, difference, less, fall, loss, take away, "negative," descend, deduct, "a certain number smaller than," "opposite of"...
C. x, ·	-times, multiply, product, "of," "double," "triple," "powers," "twice"...
D. ÷	-divide, "fractions," goes into, quotient...
III. Relation Symbol	
A. =	-is equal to, is the same as...
B. >	-is greater than, is more than...
C. <	-is less than, is smaller than...
IV. Grouping Symbols ( ), [ ], { }	-"the quantity..." (there may be no overt identification), "the sum of," "the product of," "the difference of," "the quotient of"...
V. Placeholder Symbols n, x, y...	-"the number," " the unknown"...

The following are some examples of seemingly complicated English expressions which have been "translated" into mathematical symbolism.

	English	Mathematics
1.	Twice a number is 28.	$2n=28$
2.	The difference of a number and 7 is 20.	$X-7=20$
3.	Six less than twice a number is 14.	$2m-6=14$
4.	The sum of 5 times a number and 18 is 58.	$5y+8=58$
5.	4 is 1 less than the quotient of a number and 4.	$4 = n/4 - 1$
6.	39 is the result of increasing the product.	$39=7n+5$
7.	20% of what number is 52?	$20/100 \cdot n = 52$
8.	What percent of 22 is 2?	$n/100 \cdot 22 = 2$
9.	What is 25% of 48?	$r = 25/100 \cdot 48$
10.	What is the measure of an angle if the sum of its complement and its supplement is 120 more than the angle itself?	$(90-n)+(180-n)=120+n$

Conclusion

Finally, it must be made clear that as mathematics educators we do not attempt to make the content of mathematics so structured that creativity and spontaneity are stifled. However, as the creative writer must first develop a strong foundation in the fundamentals of sentence structure, so must the mathematics student

be prepared before going into theoretical and highly abstract mathematical experiences.

In addition, we must consider that problem solving has, of late, become a major thrust in all educational disciplines. Any help we can give the student which will better prepare him/her for this type of analysis will be of use, whether it be the categorization of problems or the general nature of logical thinking.

It is hoped that this monograph will be the means to that end.

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